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THE UTILIZATION OF SAWMILL WASTE AND SAWDUST FOR FUEL

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The Utilization of Sawmill Waste and Sawdust for Fuel

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Introduction

The various processes involved in the manufacture of logs into lumber produce a considerable quantity of wood substance which cannot be used as lumber. This material constitutes the so-called " mill-waste " in a sawmill, and includes bark-covered slabwood, lumber trimmings containing defects, broken or otherwise defective material, and sawdust and shavings. It is not entirely a waste product, since much of it is used for special purposes, but in comparison with lumber its value is very low. Studies carried out by the Forest Products Laboratories show that there has been a very marked increase in the use of this waste material, especially at those mills of the Southern Coast region of British Columbia which are accessible by truck or scow to large wood-using centres.

The use of sawdust and other forms of mill-waste for fuel disposes of the greatest proportion of this waste material, the development of the sawdust burner for domestic heating having been an important factor in this connection. It is the purpose of this publication to deal in detail with this phase of waste utilization only. Other uses for mill-waste are described in detail in previous reports issued by the Vancouver Laboratory.*

Mill-waste and Sawdust for Domestic Heating

The waste products of a sawmill, generally speaking, occur in two forms, namely, (1) sawdust, which requires no further preparation for use as fuel, and (2) other material which requires more or less handling and preparation to make it suitable for marketing. Throughout this publication " mill-waste " may be taken as applying to this latter class of material, and, to avoid confusion, sawdust is referred to as a separate product.

The mill-waste not utilized for special manufactured products may be either cut into lengths for sale as firewood or manufactured into hogged fuel.

* Information on the volume and forms of mill-waste is contained in Forest Service Bulletin No. 83, "Sawmill Waste and Its Utilization in British Columbia," by J. H. Jenkins, 1931).

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UTILIZATION OF MILL-WASTE FOR FIREWOOD
A load of Douglas fir slabwood for domestic heating.

FIREWOOD AND SAWDUST BUNKERS AT A BRITISH COLUMBIA SAWMILL

Millwaste is removed from the waste conveyer into the firewood bunkers shown on the right. Sawdust, to be used for house-heating, is being loaded into the truck shown in rear centre

At Douglas fir sawmills in British Columbia having well-organized firewood departments, the mill-waste is selected from the waste conveyer, trimmed to 16-inch lengths, and then sorted into various classes of firewood. The main classes of firewood are the following:—

Slabs, comprising the half-round-shaped slabwood, heavily bark-covered produced on the head-rig when the log is squared;

Edgings, comprising the quarter-round-shaped slabwood, bark-covered, produced when lumber is manufactured by the edger;

Inside fir, comprising the ends of lumber, free from bark, trimmed in the sawmill;

Kindling, comprising pieces trimmed from the seasoned lumber in the planing mill.

Kindling is not a form of sawmill waste proper, being produced entirely at the planing mill.

Slabs and edgings sold as firewood contain a high percentage of moisture. They are generally air-dried prior to use, and are also burned unseasoned as a furnace fuel in mixture with coal.

In certain of the Douglas fir mills, located in or near a large city, the firewood is sold to a fuel company at the slasher saws, the final sorting into firewood bunkers being done by employees of the fuel company. In other mills, firewood is sold by the load at the bunkers to owners of wood trucks. Occasionally the sorting, sale, and delivery of firewood to the consumer is handled by the sawmill company. In the cities, the cost of delivery is an appreciable item, the contract price generally ranging from $1.50 to $2 per cord. The cost of removing firewood from the waste conveyer and sorting may vary from $0.25 to about $0.75, according to the thoroughness of the sorting and handling arrangements.

Some mills in the Coast and Southern Interior regions, although not situated in any large firewood-using centres, ship selected mill-waste firewood by railway to suitable markets. A limited number of mills situated in the Fraser Valley and on Vancouver Island are provided with fresh-water log-ponds and ship their firewood to Vancouver and Victoria, respectively, the market price for so-called "fresh-water wood" being slightly higher than for wood cut from logs sawn by tide-water mills.

The use of sawdust as a fuel for the heating of dwelling-houses, apartments, and theatres is now of great importance in those portions of British Columbia accessible to suitable supplies. The sawdust used is the normal sawdust produced when sawlogs are converted into lumber, and it is used unseasoned as it comes from the saw. A special attachment to the furnace is necessary when sawdust is being burned. Very satisfactory results have been obtained from these sawdust-burners. They are economical in operation and easily controlled, and deliver a steady heat. The use of sawdust-burners has extended rapidly, and it is estimated that there are approximately 15,000 now in use in Vancouver and vicinity.

The sale and distribution of sawdust has now become a well-organized business on the Pacific Coast. The sawdust is usually handled by independent fuel companies, who purchase it from the sawmill at the fuel-bunkers. It is delivered either in bulk or in sacks. Delivery in bulk is possible only where the storage space is near a roadway. When the sawdust is delivered in sacks the price is slightly higher, but this includes the placing of the fuel in the house basement.

The cost of transportation and of sacking the sawdust for delivery to dwelling-houses are important items in the delivered cost of this class of fuel. The following is a schedule of retail prices in effect in Vancouver during 1935:—

Sawdust per unit of 200 cubic feet

Delivered in bulk —$3 in the summer;
$4 in the winter.
Delivered in sacks—$4 in the summer;
$5 in the winter.

The bulkiness of sawdust limits the distance to which it can be profitably transported. It is therefore only those sawmills situated close to large towns or on navigable waters that are able to dispose profitably of their surplus sawdust.

As a fuel, sawdust has the advantages of cleanliness, economy of operation, and steadiness of combustion. Its disadvantages result from its bulk, which involves greater handling and storage space. Careful organization and a large reserve storage by the fuel distributors are essential to ensure that no shortage of sawdust develops, either as a result of sudden demands by the consumer or from an unforeseen closing down of source of supply. A recent development is the use in sawdust-burners of a mixture of sawdust and carefully screened hogged fuel made from mill-waste by a special hog.

Mill-waste and Sawdust for Power Development

As a general rule, the sawmills of British Columbia are run by either steam or electric power, which is produced directly or indirectly by burning sawdust and shavings, supplemented at times by hogged fuel. This fuel is carried by conveyers to fuel-bunkers, from which it is fed by gravity into the combustion chamber, where it burns in cone-shaped piles.

The amount of fuel required by the individual sawmill varies greatly with the season of the year, the efficiency of the power plant, and the steam requirements of the dry-kiln, reaching a maximum during the winter months. Although the amount of sawdust and other mill-waste produced in the manufacture of lumber in British Columbia has been determined by the Laboratories, it was not possible to determine accurately the percentage of this waste production that is required by the sawmill power-plant for steam generation. So far as is known, none of the British Columbia mills actually measure the amount of sawdust consumed. Records from Douglas fir sawmills and planing mills in other districts indicate that from 4 to 6 electrical horse-power are required per thousand feet of cut per day of 10 hours, or from 30 to 45 kilowatt-hours for each thousand board feet of lumber produced. In addition, from 100 to 200 horse-power of boiler capacity is necessary for the dry-kilns, the steam-carriage feed, and the various steam cylinders about the plant. To generate this power, about one-half of one cubic foot of hogged mill-waste is required for each horse-power developed.[1]

In cases where the supply of sawdust is not sufficient for a sawmill's power-generation requirements, or where the market for slabwood is poor, the poorer grades of mill-waste are reduced by a "hog," or refuse chipper, to "hogged fuel." This hogged fuel may be used as fuel by the mill or sold to other industries for power development. As a general rule, however, the amount of sawdust produced is more than adequate to operate the sawmill power-plant and leaves a large surplus for disposal, especially in the summer months.

Certain sawmills in the Coast district, situated on navigable waters but prevented by their isolated location from selling their mill-waste and sawdust for domestic fuel, hog their wood-waste and sell it, together with their surplus sawdust, as fuel to large industrial plants such as pulp-mills. At these sawmills the refuse is loaded by conveyers into scows moored at the mill dock. The cost of handling and transportation is thereby reduced to the minimum.

[1] This statement is based on information contained in "Lumber Manufacture in the Douglas Fir Region," by H. B. Oakleaf, published in 1920 by the Commercial Journal Co., Inc., Chicago.

Hogged fuel, as produced by the standard type of sawmill hog and containing large slivers, is not satisfactory for use in the domestic type of sawdust burner. Experiments are now being made to evolve special hogs or grinding equipment that will convert surplus mill-waste into a form of fuel suitable for use in these sawdust burners. By this means, the supply of sawdust resulting from the manufacture of lumber would be augmented and the surplus mill-waste, which is often difficult to dispose of as "edgings," would be converted into a form of fuel for which there is a steady demand.

Volume and Weight of Wood Fuel

An important difference in the merchandising of fuel is that coal is sold by weight, whereas wood, sawdust, and oil are sold by volume. In the Pacific Northwest it is customary to sell firewood by single-load and double-load units, which are considered equivalent to half-cord and cord stacked measure. The Weights and Measures Act of Canada defines the standard cord for firewood as containing 128 cubic feet. To compensate for the additional space occupied by firewood when dumped or thrown into the delivery vehicle, the city of Vancouver provides that the standard delivery box for one cord shall have a volume of 168 cubic feet and for half-cord loads a volume of 84 cubic feet. These delivery boxes are measured annually and carry an inspection identification plate.

The stacked cord is a measure of convenience, as the purchaser is interested not in the cord but in its solid cubic contents of wood. H. H. Chapman in "Forest Mensuration" (John Wiley and Sons, 1921) states: "In actual practice, the solid contents of a cord seldom exceed 100 cubic feet," and cites tables showing that the cubic feet of solid wood in a cord of firewood may vary from 76·8 to 96·0, depending upon the size and shape of the pieces piled. Studies made by the Laboratories on a number of delivered cords in the Southern Coast region show that the average cord (double-load) of slabs and edgings contains between 85 and 105 cubic feet of wood and bark.

On the Pacific Coast, sawdust and hogged fuel are sold by the "unit" of 200 cubic feet. The volume of actual wood in a unit is much less than the 200 cubic feet of space occupied by the unit. This wood volume varies with the coarseness of the fuel and with the tightness of packing. Studies made by the Laboratories indicate that the average unit of sawdust contains approximately 80 cubic feet of solid wood as compared to 73 cubic feet of solid wood in a unit of coarse hogged fuel.

A comparison of the volume of wood material in the various forms of wood fuel, as determined by the Vancouver Laboratory, is listed below:—

Class of Fuel	Volume of Wood Material
Slabwood—1 double load (cord) contains..	85 to 105 cubic feet
Sawdust—1 unit (200 cubic feet) contains..	80 " "
Hogged fuel—1 unit (200 cubic feet) contains	73 " "
1 cord slabwood (if hogged) will make.....	1·2 to 1·4 units
1,000 feet board measure of lumber (if hogged) will make	1·1 "

The results of a series of studies made by the Laboratories on a number of cords of mill-waste are shown in Table 1.

Table 1—DOUGLAS FIR MILL-WASTE FOR FUEL

Class	Moisture content[1]		Weight per cord	
	Range	Average	Range	Average
	Per cent	Per cent	Lb.	Lb.
Slabs	78 to 120	98	5,760 to 6,720	6,130
Edgings	90 to 176	104	4,870 to 5,370	5,140
Inside fir	36 to 48	42	4,400 to 5,560	4,830

[1]Percentage based on oven-dry weight and determined at time of delivery of fuel from sawmill.

The weight of Douglas fir sawdust, as delivered unseasoned from the sawmill, ranges around 3,400 to 3,700 pounds per unit, the average being 3,510 pounds per unit. A unit of Western hemlock sawdust weighs in the neighbourhood of 4,300 pounds per unit. The weight of a unit of hogged fuel is approximately 9 per cent lower than that shown for sawdust.

Heat Value of Wood and Sawdust

In considering the use of sawdust and other forms of mill-waste for fuel purposes, its heating value in relation to other fuels on the market must be considered. The heat value of a fuel usually refers to the quantity of heat liberated in burning one pound of the fuel. The unit of heat measurement in use among engineers is the British thermal unit (B.t.u.). For all practical purposes this is the amount of heat required to raise the temperature of one pound of water through 1 degree Fahrenheit.

The heating value of different fuels varies greatly. For coal it ranges from approximately 7,000 B.t.u. per pound for lignite to 13,500 B.t.u. per pound for the better grades of bituminous and semi-anthracite coals. The fuel oils used in domestic heating have heating values of about 166,000 B.t.u. per gallon.

The presence in the wood of resin, gums, oils, etc., in varying amounts materially affects the heating value of different species of wood. Calorific determinations made by the Vancouver Laboratory show the following heat values for certain British Columbia woods:—

Table 2.—HEAT VALUE OF CERTAIN BRITISH COLUMBIA WOODS

Species	Calorific value per pound oven-dry fuel	
	Wood	Bark
	B.t.u.	B.t.u.
Douglas fir	9,200	10,150
Western hemlock	8,500	10,000
Sitka spruce	8,100	.....
True fir (*Abies*)	7,150	9,200
Western red cedar	9,700	.....

Note.—Although the calorific value per pound of oven-dry wood is high for Western red cedar, the low weight of this wood materially reduces its available heat value per unit (200 cubic feet).

The presence of moisture in varying amounts has a marked effect on the heat available from wood and sawdust. There is a reduction in the available heat when the fuel is burned, due to the heat required to evaporate and superheat the water contained in the wood. Further, any increase in the proportion of moisture in a pound of wood fuel causes a corresponding decrease in the amount of wood substance, thus further reducing the heating value per pound of fuel. It has been found that the loss of heat due to the presence of moisture in fuel may be expressed as follows:—

Heat loss in British thermal units per pound of fuel $= w\ (1090 - t + 0 \cdot 46\ tg)$
where $w =$ weight of free moisture per pound of fuel
$t =$ temperature of fuel as received, in degrees Fahrenheit
$tg =$ temperature of chimney gases, in degrees Fahrenheit.

In referring to the amount of moisture in wood, it is customary to express it as a percentage of either the oven-dry weight of the wood or of the green or original weight. The first method, in which the constant oven-dry weight of the sample is employed, is in general use for lumber seasoning and wood technology. The second method, in which the green weight is used as a basis of calculation, is, however, often used in referring to the moisture content of fuels. For con-

verting the percentage of moisture based on the green weight (as in fuels) to the percentage of moisture based on the oven-dry weight (as in lumber seasoning) the following formula may be used.

$$D = \frac{G}{100 - G} \times 100$$

where D = percentage of moisture based on oven-dry weight
G = percentage of moisture based on original weight.

The moisture content of wood fuel varies with the species and whether it is heartwood or sapwood. The moisture content of green slabwood and edgings, which contain a considerable percentage of sapwood, is high, especially in the case of Western hemlock and Sitka spruce. An appreciable reduction in moisture content is brought about, however, when the wood has been properly piled and air-seasoned during the summer; by this procedure moisture contents as low as 15 per cent (based on oven-dry weight) may be obtained.

The moisture-content range of green sawdust is shown in Columns A and B of Table 3. Green sawdust placed in storage in house basements will dry out on the exposed surface, but little drying occurs in the interior of the pile. In the interior of a pile of sawdust stored for eight months in a basement it was found that the moisture content dropped approximately from 60 per cent to 40 per cent (based on the oven-dry weight).

In considering the effect of moisture content on the calorific value of a fuel, there is an important difference between wood fuel and coal. Coal is sold by weight, so that any reduction in the calorific value per pound is a direct loss, whereas wood and sawdust are sold by volume, weight being disregarded. As a result, while the presence of moisture in wood decreases the heating value of each pound of fuel, at the same time it increases the weight of the unit. This is shown for sawdust in Table 3, which is based on studies made by the Vancouver Laboratory:—

TABLE 3.—HEATING VALUE OF SAWDUST

Species	Moisture content		Weight of unit	Calorific value per pound		Available heat	
	A	B		Oven-dry	As collected	Per lb.	Per unit
	Per cent	Per cent	Lb.	B.t.u.	B.t.u.	B.t.u.	B.t.u.
Douglas fir	60	37	3,510	9,200	5,800	5,330	18,708,000
Western hemlock	109	52	4,315	8,500	4,080	3,435	14,822,000
Western red cedar	77	44	2,700	9,700	5,480	4,930	13,311,000
Sitka spruce	92	48	3,320	8,100	4,210	3,605	11,968,000

NOTE.—Moisture content: Column A, based on oven-dry weight; Column B, based on original weight.

In Table 3 the available-heat calculations are based on an assumed stack temperature of 500° Fahrenheit and take no cognizance of heat carried away in the dry flue-gases and heat lost from the combustion of the free hydrogen in the fuel. In burning sawdust having a high moisture content, more draft is necessary than in burning dry fuel; this has the effect of increasing the amount of excess air admitted, with a resultant higher loss of heat. In cases where there has been an appreciable decrease in the moisture content of the sawdust, too rapid combustion may occur unless care is taken to reduce the draft.

The greater part of the sawdust used for domestic heating in British Columbia is Douglas fir. This is due to its high heat value per unit and satisfactory burning qualities and to the large supplies in the Southern Coast region accessible to the main centres of population. In other forest regions of the province, the

available local species such as Engelmann spruce and ponderosa pine are used in limited quantities. In the Coast region Western hemlock is also used, being sold at a price which compensates for its lower calorific value and high moisture content. Available information indicates that hemlock hogged fuel and sawdust should be comparatively coarse to prevent the wet fuel from packing too tightly when being burned.

Storage of Sawdust

The maximum consumption of sawdust for house heating occurs during the cold weather, when the amount required by the saw-mill power-plants is also at a maximum. Unless a reserve is accumulated during the summer, either by the fuel company or by the individual user, a shortage is likely to occur during the winter. Accumulation and storage are therefore imperative in order to maintain the sawdust fuel business on a sound basis.

To ensure continuity of supply, it is recommended that the sawdust user have as large a storage bin as possible, so that a private reserve for the winter may be built up during the summer months when the supply is at the maximum. For the average five- to seven-roomed house, bins holding from four to ten units of sawdust are generally constructed in the house basement. No trouble from staining or sweating is experienced in the storage of Douglas fir sawdust in house basements.

Recognizing the necessity for summer storage of surplus fuel sawdust, the Forest Products Laboratories have made studies on Douglas fir to determine the effect of various methods of storage for different periods on the heating value of sawdust and the maximum temperature rise occurring in the interior of large piles of unseasoned sawdust, stored under different conditions. These studies showed that the following conclusions may be drawn regarding storage[1]:—

1. The storage of unseasoned sawdust under cover for periods of one year, at least, is entirely feasible. The moisture content and burning qualities were found to be satisfactory at the end of the storage period.

2. Storage of sawdust in the open for one winter only will result in an increase in moisture content sufficient to reduce the available heat value materially. This method of storage therefore seems to be inadvisable.

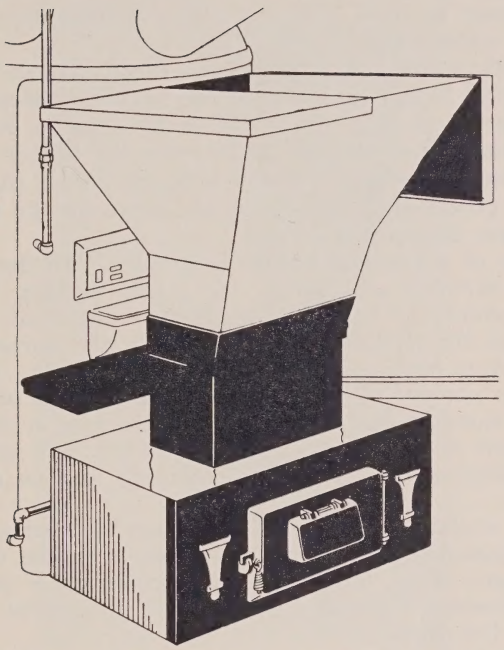
3. The danger of unseasoned sawdust "heating" when stored in quantities up to 20 units in house basements is negligible. The temperature in the centre of the pile, in bins containing from 4 to 8 units, was not more than 5 degrees Fahrenheit above that of the surrounding air. The maximum temperatures recorded in larger piles of about 20 units was 85 degrees Fahrenheit, this being only 20 degrees Fahrenheit above that of the surrounding air. Cases have been noted where higher temperatures than these have occurred as the result of abnormal conditions, but the Laboratory has had no case brought to its attention where the temperature rise within the pile was sufficiently high to prove harmful or dangerous.

Many fuel companies now accumulate and store large quantities of sawdust during the summer months to assist in meeting any winter shortage. In addition, a very appreciable volume of sawdust is placed in storage in house basements each summer. The sale of sawdust is therefore now well distributed throughout the year.

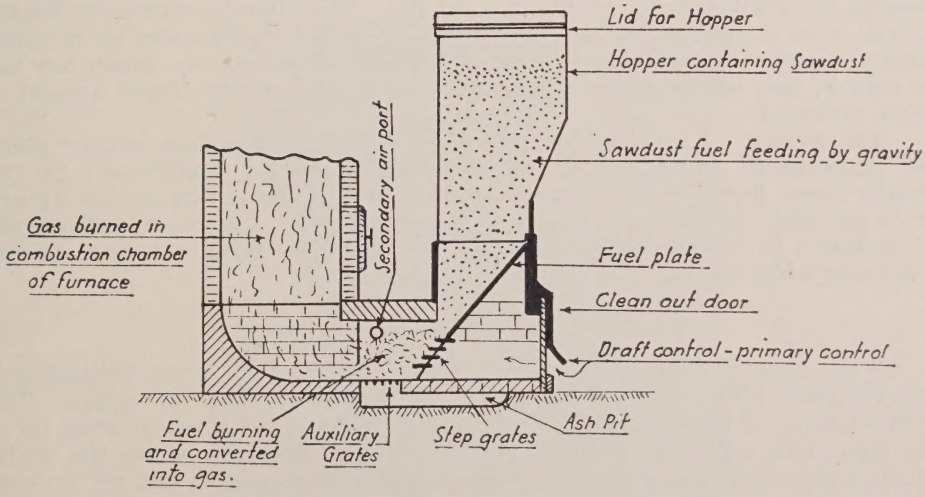
Sawdust-burning Equipment

For domestic heating with sawdust a special attachment to the furnace is necessary. This burner consists of a fuel hopper with a Dutch-oven extension to the ordinary furnace firebox. In installing one of these burners, the furnace grates used with coal or wood are removed, the interior of the ash-pit is lined

[1] The results are described in detail in Forest Service Circular No. 33, "Effect of Moisture Content and Storage on the Heating Value of Sawdust," by J. H. Jenkins and F. W. Guernsey (1932).



TYPICAL ATTACHMENT TO THE FRONT OF A HEATING PLANT
FOR BURNING SAWDUST



SECTION OF SAWDUST BURNER ATTACHED TO FURNACE

with fire-brick, and the burner is then built on in place of the ash-pit door. Coils for heating service water may be installed either in the firebox or in the burner. Sawdust burners may be used with any make of domestic furnace, whether of the hot-air or hot-water type.

Several manufacturers have placed sawdust-burners on the market, but, in general, they conform to two main types—one having the step grate and the other using a straight grate sloping to a perforated plate. A furnace specially designed for the burning of sawdust and having the burner incorporated in the design has also been developed. Small burners, which enable sawdust to be burned in kitchen ranges and cook stoves and serve for the heating of water for domestic service, are also on the market.

The operation of a sawdust burner is simple. The fire is lit by means of paper and a few handfuls of sawdust, the hopper is then filled with sawdust, and the rate of combustion is controlled by the volume of air admitted to the burner. So long as the hopper contains sawdust, the burner operates steadily, the rate of combustion being regulated solely by the draft. For night operation, when the minimum amount of heat is required, the drafts of the burner may be closed so that the sawdust only smoulders. As the rate of combustion is dependent on the amount of air admitted to the burner, it is essential for positive control that all unnecessary air-leaks be plugged and no air admitted except through the drafts.

Thermostatic control is used only to a very limited extent with sawdust burners. Where installed, the thermostat operates on the draft control on the front of the burner. This limited use of thermostats is probably due to the steadiness of combustion that may be obtained in sawdust burners using only manual control of the draft.

Combustion tests and flue-gas analyses made by the Laboratories indicated that in burners having exterior "secondary air-ports" the most complete and efficient combustion occurs when these ports are nearly closed. When opened too wide, too much air is admitted over the fire, with a resultant cooling effect.

For night operation, the rate of combustion in a properly installed sawdust-burner can be so reduced by closing the drafts that the sawdust only smoulders and less than a quarter of a hopper of fuel is used. In the morning, however, opening the drafts quickly results in a hot fire. The attention necessary for the operation of a sawdust-burner consists of filling the fuel-hopper as required, passing a poker over the grates once each twenty-four hours to loosen any ash or clinker, and (about twice a month) cleaning out the very small amount of ashes produced.

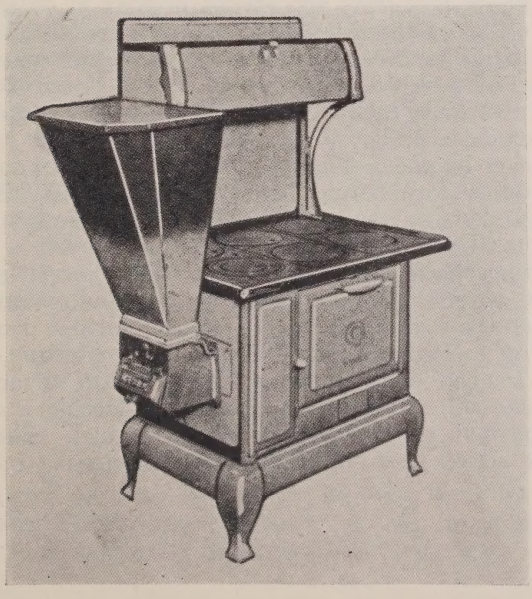
The amount of sawdust burned varies with the size of the heating plant, the temperature maintained in the house, and weather conditions. On the Pacific Coast, however, the normal consumption for heating ranges from 1½ to 2 units per room per winter. On this basis, the cost in Vancouver and vicinity of heating a five-roomed house for the winter would be about $35 with sawdust purchased when the summer rates were in effect.

Care of Sawdust-burning Equipment

When wood is used as a fuel, certain of the products of wood distillation in the flue-gases often condense on the cooler portions of long stovepipes. This occurs mainly at night when the drafts are closed, and a leaking of wood tar at the pipe joints will often be noted in the morning, prior to opening the drafts. Most of this wood tar is burnt out when the fire is increased, but the presence of the wood tars and creosotes mixed with the soot tends to increase the corrosion of furnace pipes.

The development of sawdust-burning equipment has brought the claim that sawdust is a direct cause of furnace corrosion. This claim is apparently based upon the idea that sawdust contains a considerable quantity of salt as a result of the immersion of logs in sea-water. Definite information is not available

HOT-WATER HEATER WITH SAWDUST BURNER



KITCHEN UNIT WITH SAWDUST BURNER INSTALLED

as to the extent to which salt water penetrates sawlogs while in the boom, but it appears very unlikely that any appreciable amount of sea-water would penetrate beyond the sapwood, much of which is removed with the slabbing of the log.

This is particularly true for Douglas fir, and as practically all Douglas fir sawdust results from the manufacture of the heartwood into lumber, the presence of any harmful quantity of salt in the fuel seems doubtful. There have been a number of instances where heating plants, using sawdust for fuel, have been taken out because of corrosion and burning out. The difficulty lies in determining whether the failure was due to the presence of certain salts in the sawdust, or to neglect, faulty operation, or normal wear which would have caused failure of the heating plant regardless of the fuel.

Little trouble from corrosion, regardless of fuel used, is experienced with hot-air furnaces. All cases of corrosion in plants using sawdust for fuel reported to the Laboratory were in hot-water boilers. In these boilers, the corrosion can be divided into two classes: first, corrosion from the water side of the metal, brought about by the action of the hot water inside the boiler; second, corrosion which takes place on the fire side of the metal. Any corrosive effect that sawdust may have is confined to the second form, and discussion in this report is limited to possible causes of the development of this corrosion.

The electro-chemical theory of corrosion in iron is now generally accepted. Experiments have shown that the mechanism of the corrosion process is very similar to the reactions occurring in a primary electric cell. Under certain conditions, adjacent areas on the surface of the iron may assume the anode-cathode[1] relationship resulting in corrosion. Accumulations of soot in flues, stovepipes, and other portions of the heating plant have a very decided accelerative action on the electro-chemical corrosion of the metal. Furnace soot, regardless of fuel used, consists of a high percentage of carbon, which serves as an excellent cathode. In the event of any salts in the fuel being volatilized in the furnace and condensed in the flues, their presence (especially when the plant is cold) would help to maintain a high moisture content and increase the electric conductivity of the soot.

The presence of chlorine and sulphur in the soot from wood, sawdust, and coal does not necessarily mean that it resulted from salt water in the fuel, since small amounts of these chemicals are always present in coal and wood. Some time ago, through the co-operation of the Department of Chemistry of the University of British Columbia, an analysis of the chlorine and sulphur content of selected samples of soot was made to determine if an excessive amount of salt were present in sawdust fuel. The results did not vary greatly for the three classes of fuel: sawdust, millwood, and coal.

The investigation by the Laboratory of a number of complaints regarding the corrosion of hot-water heating boilers indicated that this corrosion was largely a result of shutting the boiler down for the summer in a dirty and undrained condition. During the period when the boiler is not in use, it is cooled down to atmospheric temperature. If the boiler is left undrained, the temperature of the water it contains changes less rapidly than that of the surrounding air. When the room temperature changes so that it is higher than that of the boiler, the boiler surfaces may "sweat," and moisture from the air will be precipitated on the cool metal surfaces. Moisture on surfaces covered with a deposit of soot or ash will usually form an acid (hydrochloric or sulphuric) with the compounds deposited from the combustion of the fuel. Since these are active acids, the corrosive action may be rapid if they are present in any quantities.

[1] The active dissolving electrode of a primary cell is the anode, the other electrode being the cathode.

In view of the danger of corrosion occurring during the summer shut-down period, regardless of the type of fuel used, it is suggested that the following precautions be observed in shutting down heating units:—

1. Drain the boiler in hot-water heating plants;
2. Clean the interior of the combustion chamber and all flues thoroughly, removing all soot and ash;
3. Apply coating of heavy non-vaporizing oil to cleaned metal surfaces in firebox and flues to prevent condensation of moisture.

In addition, regardless of type of furnace, the stovepipes should be taken down, cleaned, oil-coated, and placed in dry storage for the summer. These precautions, if applied as soon as the furnace is shut down, will materially lengthen the life of these pipes.

Briquetting of Mill-Waste

The compression of sawdust, shavings, and other forms of wood waste into briquette form for fuel purposes has been successfully carried on in Europe for a number of years, but has met with little success in the Western States and Canada. The requisites for success in briquetting mill-waste are (*a*) a large and continuous supply of suitable raw materials, (*b*) low production costs, and (*c*) a ready sale for the finished product at fair prices. As a general rule, the briquettes must be marketed in the immediate region of production.

There are a number of briquetting systems in use. In general, however, the briquette is made by compressing sawdust or hogged fuel in a heavy press. The hardness of the briquette depends upon the process used and upon the pressure applied. The preliminary drying of the wood material used is a necessary step, as it is practically impossible to make wet wood cohere properly. The continuous drying of large quantities of wood waste offers a difficult problem in the briquetting process. In some briquetting systems coal-tar pitch, or other binding material, is mixed with the wood waste before compression. In other systems, very heavy pressures are used, causing the resinous material in the wood to serve as a natural binder.

Wood briquettes are sometimes produced as a preliminary to distillation for the manufacture of wood by-products and charcoal, or, conversely, charcoal briquettes are produced from fines produced by the distillation of wood.

In 1930 a machine was developed for the manufacture of briquettes from dry planing-mill refuse. The briquette produced is cylindrical in form, $4\frac{1}{8}$ inches in diameter, and $12\frac{3}{4}$ inches long. It is slightly over three times as dense as wood and weighs eight pounds. These briquettes are in use for cooking and for open fireplaces. A limited number of these machines is now in use in the Western States and in 1935 a total of 43,481 tons of these briquettes was produced. The system used will not work with wet refuse, and experiments are being made in the drying of sawmill waste preparatory to briquetting. Until economical methods of drying large quantities of wet sawmill waste are evolved, it would appear that the present methods of handling this material for fuel will continue.

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